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(54) Improvements in or relating to flame monitors

(57) This invention relates to a flame monitor which has a sensing circuit 11 with a flame sensor 10 and a sensing relay 13 which switches a sensing switch 5 which is connected in parallel with a bridging switch 4 connected to a supply line 1. With one contact, sensing switch 5 controls a fuel valve 7 and with the other contact a circuit 16 with two alternatively energized relays, a bridging relay 24 and a relay 27 for switching the flame loss simulation and a timing device 30. The bridging switch 4 switches the fuel valve 7 and a safety circuit 3 with a safety relay 22 for switching a safety switch 2 located in the supply line and a parallel connected second timing device 31. During operation the first timing device 30 is discharged, causing the bridging switch 4 to provide parallel energization of the fuel valve 7 and then the flame loss simulation is actuated by relay 27 so that sensing switch 5 switches power to circuit 16 and timing device 30 is charged. Relay 13 then removes the flame loss simulation from the flame sensing circuit 11, so that sensing switch 5 again energizes fuel valve 7, while bridging switch 4 switches safety circuit 3. The cycle then starts again.

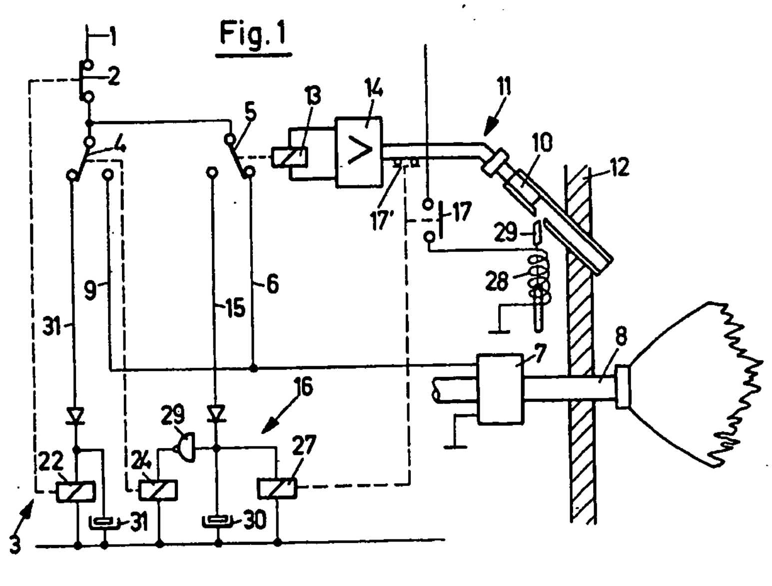

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Fig. 1

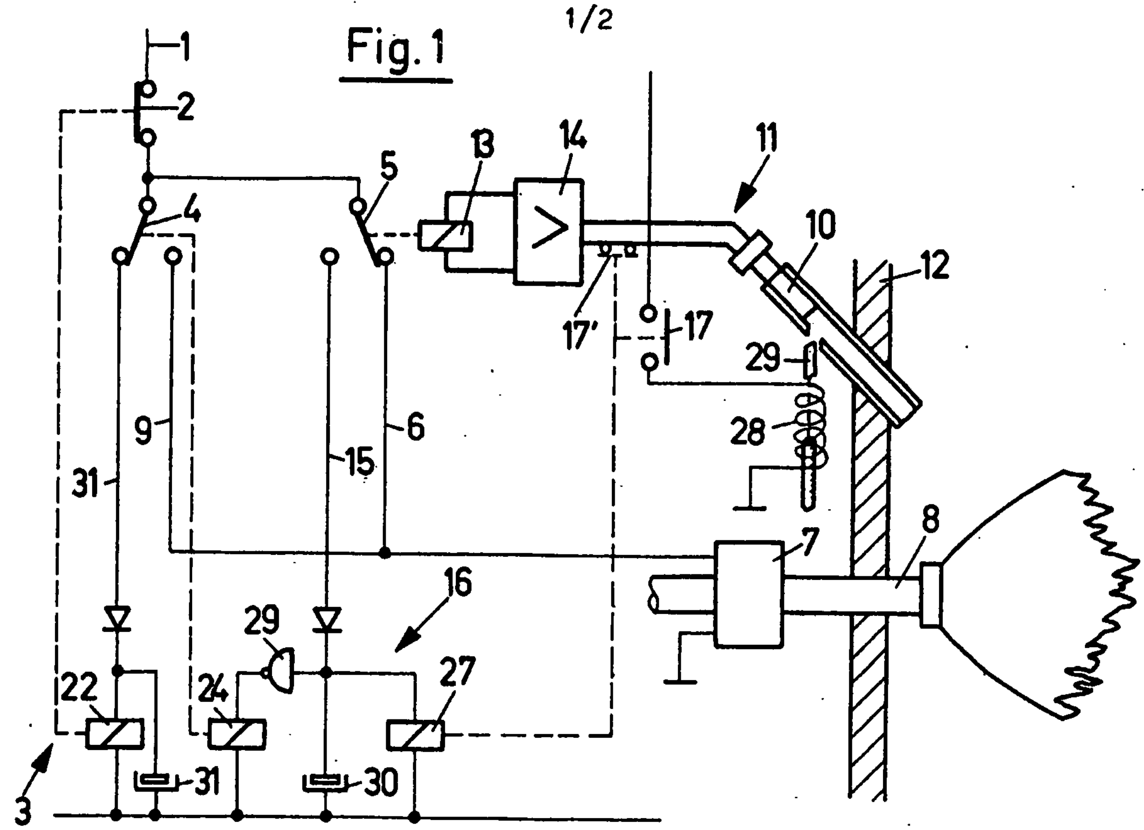


Fig. 2

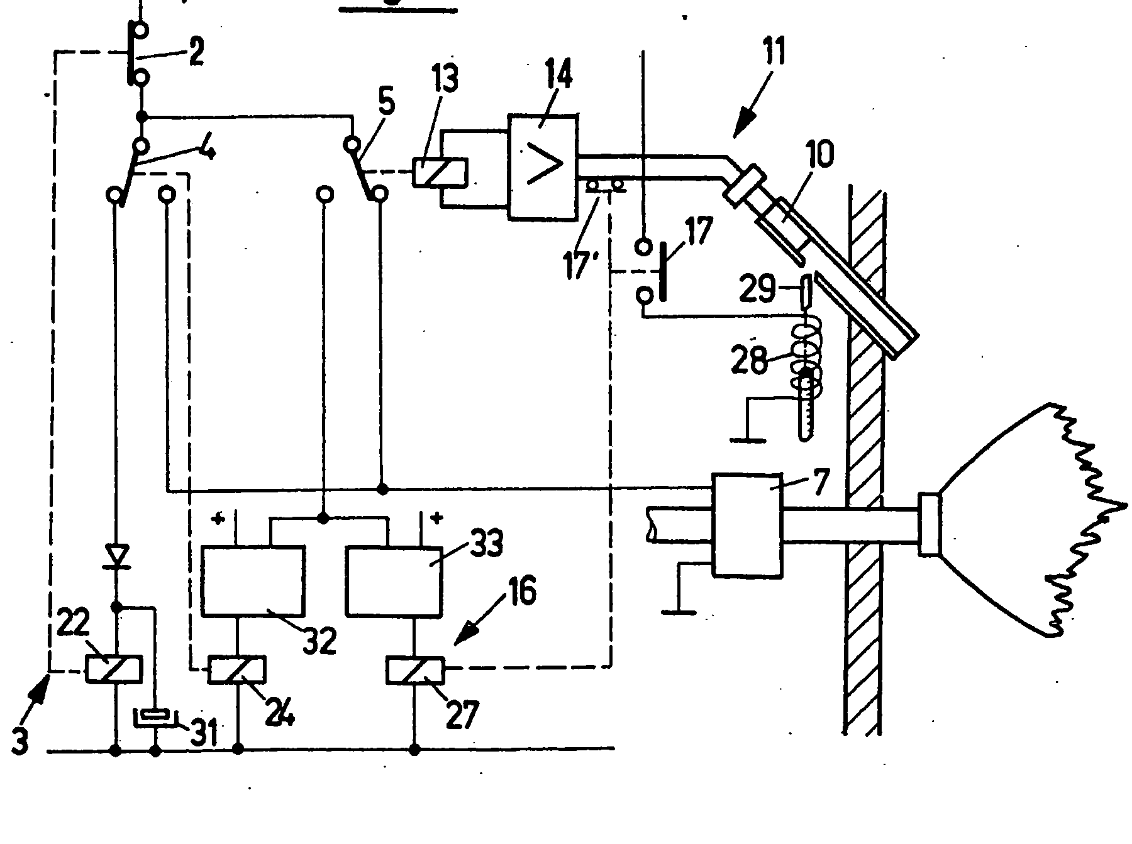


Fig. 4

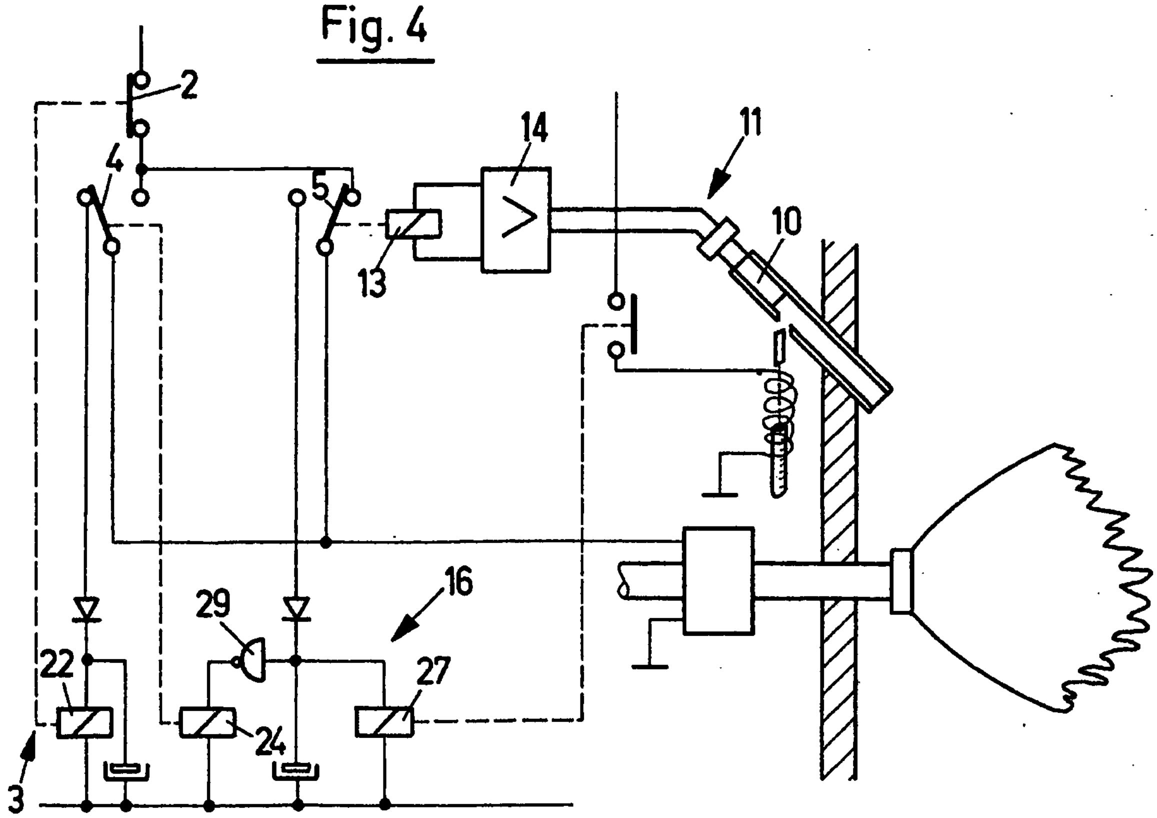
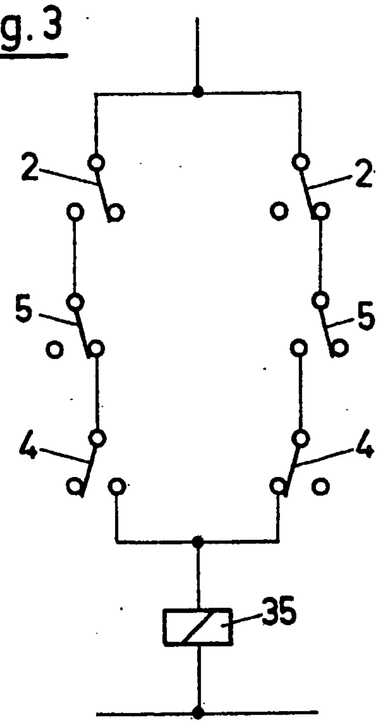


Fig. 3



SPECIFICATION

Improvements in or relating to flame monitors

The present invention relates to flame monitors e.g. for furnaces having an oil or gas burner, such monitors being of the type having a flame sensing circuit with a flame sensor for monitoring the burner flame and switches for controlling the fuel supply.

Various flame monitor constructions are known. As they are of considerable importance for the safe operation of furnaces and the like, it is known to supervise individual components of the flame sensing circuit by various circuit and control techniques. However, this self-monitoring involves considerable circuit complexity without achieving complete reliability of operation because of the dependence of the self-monitoring on the fault-free operation of the self-monitoring circuit components themselves. In such devices, the flame sensor is periodically shielded from the radiation emission from the flame by a cover placed in front of the sensor. During the covering of the flame sensor, the flame sensing relay remains energized, which energization is achieved by suitable circuit techniques.

It is an object of the invention to provide a circuit which accomplishes self-monitoring in such a way that the flame monitor is monitored by the flame sensor up to and including the switch contacts which control the fuel valve.

A further object is to provide such a circuit which avoids complex circuitry and uses simple, commercially available circuit components.

Yet another object is to provide a monitoring system in which a sensing switch is connected in parallel with a bridging switch for the fuel valve and, in the event of flame loss, can be connected with a circuit having two parallel connected alternately operated relays for switching the bridging switch and the element and a timing mechanism. As a result, the operation of the flame sensor and the bridging circuit, as well as the sensing switch, can be checked in a random sequence.

The invention consists in a flame monitor system for use with a fuel burner of the type having a burner, a fuel supply, a valve for controlling the flow of fuel to the burner and a flame sensor for producing a flame signal indicative of the existence of a flame at the burner, wherein the monitor system comprises a first switch responsive to the flame signal for opening the fuel valve to permit flow of fuel to the burner, means operatively associated with the sensor for simulating a loss of flame and causing temporary loss of the flame signal, a bridging switch for maintaining the fuel valve open when the simulating means causes loss of the flame signal, second and third alternatively operable switches for actuating the simulating means and the bridging switch, and a timer for periodically operating the second and third switches.

In order that the invention may be more clearly understood, certain embodiment thereof will now be described with reference to the accompanying drawings, in which:

Fig. 1 is a schematic circuit diagram of a first embodiment of a flame monitor for an oil or gas burner,

Fig. 2 is a schematic circuit diagram of a second embodiment,

Fig. 3 is a schematic circuit diagram of a circuit arrangement for recognizing and storing a fault in a flame monitor, this circuit being usable in the system of the invention, and

Fig. 4 is a schematic circuit diagram of a third embodiment of a flame monitor in accordance with the invention.

Referring now to the drawings, the flame monitors shown therein are usually part of an automatic furnace or the like. Thus, the components necessary for the operation of the burner are conventional and have been omitted, except when they are necessary for explaining the flame monitor circuit.

In Fig. 1, the position of the contacts corresponds to the operating position. As shown therein, a safety switch 2, which constitutes a normally closed contact set of an electromagnetic relay, forms part of a safety circuit 3 and is connected in series in a supply line 1 connected to a source of power. Safety switch 2 is connected to the movable contacts of a bridging switch 4 and a sensing switch 5, switches 4 and 5 being single pole, double throw contact sets of relays operated by energization of relay windings 24 and 13, respectively. In the position shown in Fig. 1, the sensing switch 5 connects the supply line 1 with a line 6 to a fuel valve 7 of a burner 8. A line 9 which is connected to the open contact of switch 4 in the position shown in Fig. 1 constitutes a parallel connection to valve 7 but, as shown, is interrupted in the represented position.

A flame sensor 10 of a flame sensing switch indicated generally at 11 is positioned in the wall 12 of a combustion chamber so that the sensor can monitor the flame of burner 8 and, when a flame is present, can produce a flame signal. The flame sensing circuit 11 includes a sensing relay winding 13 responsive to the flame signal for operating switch 5, and the remaining components of the sensing circuit are diagrammatically represented by an amplifier 14.

One line 15 of a circuit indicated generally at 16 is connected to the other, open contact of sensing switch 5. Circuit 16 includes a bridging relay winding 24 for switching the bridging switch 4, and a flame loss relay 27 for switching a flame loss switch 17 of an element for simulating a flame loss condition. In Fig. 1, the element for simulating the flame loss is a lifting magnet 28 which carries a mask 29 movable into and out of the emission path so that, when winding 28 is energized mask 29 functions to shield flame sensor 10 from radiation from the flame.

The flame loss device including elements 28 and 29 is only necessary in the case of passive sensors such as, for example, those with a photoresistor, an ultra-violet responsive device, or

the like. If an active flame sensor, such as a thermocouple, photovoltaic cell, ionization rod, or the like is used, there is no need for the flame loss element 28, 29 and it is sufficient if switch 17 is replaced by a switch 17', shown as an alternative arrangement in Fig. 1, which interrupts a supply line to the flame sensor 10 as soon as the flame loss relay 27 of circuit 16 is deenergized.

Two relay windings 24 and 27 are connected in parallel circuit relationship, so as to be alternatively operated, or inverting, relays as represented by an inverter 29 in series with the bridging relay 24. Thus, viewed in its simplest form, if one relay is energized, the other relay is deenergized.

It should be recognized, however, that the two relays do not necessarily change state at precisely the same time. For reasons of circuit safety, it may be desirable for relay 24 to be energized slightly before the deenergization of relay 27, as will be recognized from the following description. In the normal operating condition, flame loss relay 27 is energized and bridging relay 24 is deenergized. A timing mechanism 30, such as an electromechanical timer or, as shown, a capacitor, is connected in parallel with the two relays 24 and 27.

The safety circuit 3 includes a line 31, a safety relay winding 22 for operating switch 2, and a timing mechanism 31 which is connected in parallel with the winding of safety relay 22.

The flame monitor illustrated in Fig. 1 operates in the following manner. In the operating position, fuel valve 7 is opened and flame sensor 10 is activated. The timing mechanism 30 has not yet run down, and, if it is a capacitor, it still has sufficient charge to maintain relays 24 and 27 in their operating positions. As stated hereinbefore, relay 24 is deenergized while flame loss relay 27, together with the sensing relay 13 and safety relay 22, are energized. After a predetermined time, the timing mechanism 30 is discharged to such an extent that inverter 29 responds and bridging relay 24 is energized. Bridging switch 4 then switches so that lines 6 and 9 are connected in parallel circuit relationship.

On further discharge of the capacitor constituting the timing mechanism, the flame loss relay 27 is deenergized so that flame loss switch 17 closes and the flame sensor 10 is blacked out by flame loss element 29 as controlled by winding 28. Valve 7 remains open because of the connection through line 9 and switch 4. Flame sensing relay 13 is then deenergized, causing switch 5 to connect the power source to line 15. As a result of the connection with line 15, timing mechanism 30 is restarted. If that element is a capacitor, the capacitor is recharged through the diode connected in line 15. Sensing relay 13 is again energized while bridging relay 24 is deenergized. Fuel valve 7 is then supplied again by line 6. Safety relay 22 is energized again and, at the same time, the capacitor constituting the timing mechanism 31 is recharged through the diode in line 31. The capacitor constituting the timing mechanism 30 again begins its discharge and the cycle recommences.

The flame sensing apparatus as illustrated in the schematic circuit diagram of Fig. 2 is substantially the same as that of Fig. 1 and differs therefrom only in the construction of circuit 16. As shown in Fig. 2, timing circuits 32 and 33 e.g. a multivibrator combined with a divider are associated with the inverting relays 24 and 27, respectively, devices 32 and 33 being adjustable so that the time between the monitoring cycles can be selected at random, which prevents a premature failure of the mechanical components, i.e. relays 13, 22, 24 and 27, and flame loss elements 28 and 29.

The flame monitor system according to the schematic circuit diagram of Fig. 4 is also constructed in substantially the same way as that of Figs. 1 and 2 and differs only in the arrangement and connection of specific components which will be described. As will be seen from a review of the circuit diagram of Fig. 4, it differs from Fig. 1 only in the manner of connection of bridging switch 4 and sensing switch 5 through which current flows in the opposite direction as compared with switches 4 and 5 in Figs. 1 and 2. Thus, the monitoring function of the circuit remains the same.

By means of the flame monitors described it is possible reliably to monitor the circuit including the flame sensor 10 up to and including the contacts of bridging switch 4 and sensing switch 5 which control the fuel valve 17. The time during which fuel is added in an unmonitored manner can be made less than one second. The time necessary for closing the fuel valve after a loss of flame is only dependent upon the flame sensor 10, amplifier 14 and sensing relay 13 and can also be less than one second. The flame monitor according to Fig. 4, in particular, permits flexible selection of the time between the monitoring cycles. The simplicity of the circuit is illustrated by the fact that four identical relays can be used for relays 13, 22, 24 and 27. Finally, different flame monitors can be connected in parallel or in series and, consequently, different flame parameters can be monitored, for example, the ionization effect, ultraviolet emission, visible light, and the like.

Fig. 3 shows a circuit arrangement which can be connected in parallel with the flame monitor. The switches of Fig. 3 correspond to the switches provided in the flame monitor and they are therefore provided with the same reference numerals. This circuit arrangement makes it possible to recognize and store a fault or a defect in the flame monitor circuit in a memory 35 which can be a digital or a purely mechanical memory.

The consequences of faults on switches 2, 4, 5 and 17 actuated by the windings of relays 22, 24, 13 and 27, respectively, will now be described. It can be assumed that the switches are either in the off position or in the on position and that the faults occur as a result of the contacts being either fused or interrupted. It should be noted that safety switch 2 cannot become fused because it only

assumes a holding function and can be checked in conjunction with the control device belonging to the flame monitor. If switch 2 is switched off, fuel valve 7 is closed and ignition is switched off. Fault removal takes place in accordance with Fig. 4. If in the case of sensing switch 5 the contacts are fused in the off position, or interrupted in the on position, fuel valve 7 is closed and fault removal takes place in accordance with Fig. 4.

If the contacts of sensing switch 5 are interrupted in the off position, or fused in the on position, timing mechanism 30 cannot be restarted which means that bridging relay 24 remains energized and safety relay 23 is deenergized. Again, fault removal takes place according to Fig. 4.

If the contacts of flame loss switch 17 are fused, flame sensor 10 remains covered by the flame loss elements 28 and 29, and sensing relay 13 is deenergized. Fault removal takes place according to Fig. 4. When contacts are interrupted in the off position of flame loss switch 17, flame sensor 10 is not covered, timing mechanism 30 cannot be restarted, and bridging relay 24 is energized. The fault is removed according to Fig. 4.

When switch 17' is used in the flame sensing circuit 11, if its contacts become fused in the on position, the flame sensor 10 cannot be switched off, the timing mechanism 30 cannot be restarted, and the bridging relay is therefore energized. Fault removal takes place in accordance with Fig. 4.

In the event of interrupted contacts of flame loss switch 17, the flame sensor remains switched off in the on position, and sensing relay 13 is deenergized. fault removal takes place according to Fig. 4.

If the contacts of bridging switch 4 are fused in the off position or the contacts are interrupted in the on position, fuel valve 7 cannot be left open during the black-out phase. Fault removal takes place according to Fig. 4. However, if the contacts of bridging switch 4 are interrupted in the off position or are fused in the on position, the safety relay 22 is deenergized and, again, fault removal takes place according to Fig. 4. For all failure causes mentioned before always the fuel valve 7 is closed.

The above described flame monitor can also be used for monitoring the operation of other components, particularly of heating systems, such as thermostats, over pressure monitors and fuel valves.

CLAIMS

1. A flame monitor system for use with a fuel burner of the type having a burner, a fuel supply, a valve for controlling the flow of fuel to the burner and a flame sensor for producing a flame signal indicative of the existence of a flame at the burner, wherein the monitor system comprises a first switch responsive to the flame signal for opening the fuel valve to permit flow of fuel to the burner, means operatively associated with the sensor for simulating a loss of flame and causing temporary loss of the flame signal, a bridging switch for maintaining the fuel valve open when the simulating means causes loss of the flame signal, second and third alternatively operable switches for actuating the simulating means and the bridging switch, and a timing device for periodically operating the second and third switches.

2. A system according to claim 1, wherein a safety circuit is provided which includes a safety relay having an energizing winding, a second timing device in parallel circuit relationship with the energizing winding for deenergizing the energizing winding after a predetermined delay following removal of power therefrom, and a contact set connected in series circuit relationship with contacts of the first switch and the bridging switch, which latter includes contacts for applying power to the energizing winding and the second timing device when the flame signal is present.

3. A system according to claim 1, wherein the bridging switch includes a relay having an energizing winding, a contact set operative in one position to open the fuel valve, and an inverting circuit connected in series circuit connected in series circuit relationship with the energizing winding, the simulating means including means operatively associated with the sensor for causing loss of the flame signal, and a control winding, and wherein the timing device is connected in parallel circuit relationship with the control winding and with the series circuit including the energizing winding and the inverting circuit.

4. A system according to claim 1, wherein the bridging switch includes a relay having an energizing winding, and a contact set operative in one position to open the fuel valve, the simulating means including means operative associated with the sensor for causing loss of the flame signal, and a control winding, and wherein the timing device includes first and second timing devices, one of these devices being connected in series circuit relationship with the control winding and the energizing winding.

5. A system according to claim 1, wherein the first switch and the bridging switch each includes an energizing winding and a first contact set movable between two positions in response to actuation of its associated winding, and wherein at least one additional contact set is associated with the first switch and the bridging switch and operative with the first contact set thereof, said additional contact sets being connected in series circuit relationship and wherein memory means are connected in series circuit relationship with the additional contact sets for storing a record of a fault occurring in the operation of the switch.

6. A flame monitor system substantially as hereinbefore described with reference to Fig. 1 of the accompanying drawings.

7. A flame monitor system substantially as hereinbefore described with reference to Fig. 2 of the accompanying drawings.

8. A flame monitor system substantially as hereinbefore described with reference to Fig. 4 of

the accompanying drawings.

9. A circuit arrangement incorporating a flame monitor system, substantially as hereinbefore described with reference to Fig. 3 of the accompanying drawings.

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